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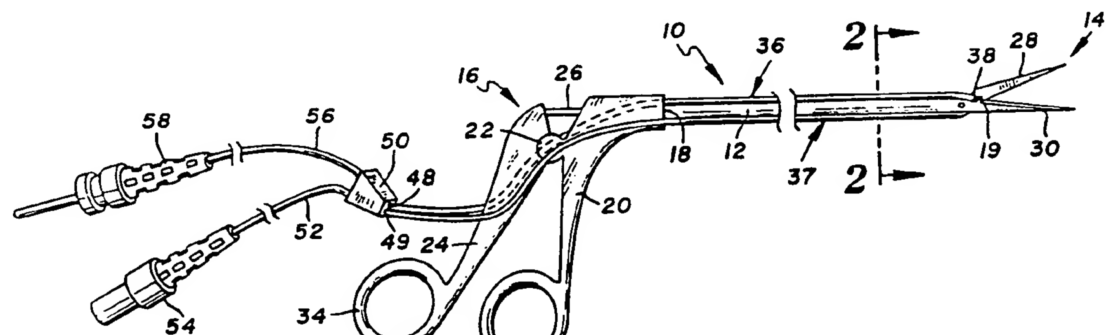

(57) Abstract

A fiber-optic viewing system affixed to surgical instruments obviates the need for a separate endoscope when performing minimally invasive surgical procedures. One or more fiber-optic assemblies (36, 37), each including a large plurality of image fibers, are suitably affixed to the instrument (10) with the fiber-optic assemblies extending along substantially the entire length of the instrument from a proximity located handle (16) to a location adjacent the working element (14) of the instrument whereby the tissue to be cut, grasped, sewn or otherwise manipulated can be viewed from the perspective of the working element. Because the fiber-optic assemblies (36, 37) are made to conform to the general shape of the instrument, the desired balance and tactile response of the instrument (10) is maintained and the fiber-optic assembly (36, 37) does not tend to obscure the surgical site (14).

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SURGICAL INSTRUMENT INCORPORATING FIBER OPTIC VIEWING SYSTEMS

BACKGROUND OF THE INVENTION

I. Field of the Invention:

This invention relates generally to surgical instruments, and more particularly to an improvement to conventional instruments which facilitates viewing of the surgical site by the surgeon from the perspective of the working end of that instrument.

II. Discussion of the Prior Art:

When performing many surgical procedures, surgeons require a clear view of the operating field and of the working end of their instruments so that the tissue structures to be cut and those to be preserved can be distinguished.

Various techniques have been developed to improve the visibility of the operating field. For example, surgical headlamps, typically mounted to a band worn on the physician's forehead, may be used to direct bright light in the direction in which the surgeon is looking. The beam from the headlamp can be used to provide illumination in an incision that would otherwise be in a shadow area if only the operating room overhead lights are being used. Another technique which has been used to improve visibility involves the use of loupes, which are binocular-like magnifying lenses adapted to be worn on a surgeon's glasses or on a headband. The magnification enables the surgeon to see details that would otherwise tend to be indistinguishable. Another device commonly used to improve visibility is the operating microscope. Such a device is designed such that there is a large working distance between the microscope's objective lenses and the surgical site under inspection. After an operating microscope is positioned over a patient, the surgeon can reach beneath the microscope and employ conventional surgical tools. Operating microscopes are available that provide two viewing systems, allowing an assisting surgeon to also view

the surgical site along with the lead surgeon. Also, operating microscopes can be equipped with a video display system for allowing greater viewing participation and for recording.

In recent years, technology has advanced to the point where minimally invasive techniques can be used in carrying out an increasing variety of surgical procedures. Rather than making a large incision to expose the surgical site to view, various types of endoscopes are used which are designed to be inserted into the body through a normal orifice or through a substantially smaller puncture or incision. Rigid endoscopes, without tools or working channels, can be used strictly to monitor a surgical procedure. Typical of such devices are laparoscopes, such as used during laparoscopic cholecystectomy procedures. The laparoscope is inserted through a small puncture wound in the abdominal wall and various cannulae are likewise inserted, allowing cutting instruments and grasping instruments to be introduced through the lumen of these cannulae as the surgical field is being observed on a display device coupled to the laparoscope.

Still other types of rigid endoscopes are also known that have a working element or tool disposed at their distal ends. Such rigid endoscopes provide excellent optical images, but they suffer from several drawbacks. First, they require precise alignment and are therefore fairly expensive to manufacture. The optical system employed does not allow the endoscope to be bent and this necessarily limits the ability of the surgeon to gain access to many areas of the body to be worked on.

A flexible endoscope, on the other hand, provides access to parts of the body that are only accessible through tortuous, curved passages. By incorporating a working channel in a flexible endoscope, the surgeon may pass a flexible tool through the endoscope to manipulate tissue at the distal end of the endoscope. With a flexible endoscope, however, it becomes difficult to position the

working end, when it is considered that the equal and opposite reaction to a force may easily push the end of a flexible endoscope away from the target tissue.

Flexible endoscopes offer a further advantage over rigid endoscopes in that with a flexible endoscope, it is possible to position a video camera in any convenient location whereas with a rigid endoscope, it must necessarily be suspended from the proximal end thereof. The additional weight of the camera makes it more difficult for the physician to manipulate the distal end of the endoscope to bring its lens system to a desired location and also seriously detracts from the tactile response provided by the instrument.

U.S. Patent 4,759,348 to Cawood describes an assembly of a flexible endoscope with a surgical instrument wherein only the endoscope's optical head is releasably clipped to the distal end portion of a surgical instrument, theoretically making it possible for the surgeon to view the working tip of the instrument. However, because it is intended that the clip-on head be secured to the surgical instrument at the time of the surgical procedure, obtaining proper alignment and focus becomes time consuming. Also, because the Cawood device only connects to the distal end portion of the surgical tool and its body does not follow or conform to the shape of the instrument, the weight of the flexible endoscope tends to dampen the tactile feel which is so important to a skilled surgeon. Moreover, a surgical device whose distal end cannot be precisely maneuvered tends to offend a surgeon's natural desire to maintain such control over that which can touch tissue. Furthermore, it presents yet another obstacle in the surgeon's field-of-view and requires a larger than necessary incision to allow entry of the endoscope and the surgical tool through the same opening.

OBJECTS

It is accordingly a principal object of the present invention to provide a variety of improved surgical

instruments incorporating one or more fiber optic viewing assemblies having a cross-sectional size allowing them to closely conform to the shape profile of the particular instrument employed and whose distal ends are accurately focused on the working element of the instrument.

Another object of the invention is to provide a variety of surgical instruments, such as used in arthroscopic, laparoscopic or other endoscopic procedures, but with each equipped with small diameter fiber optic viewing assemblies where the presence of the fiber optic viewing assemblies does not detract from the normal tactile feel presented to the surgeon as the instrument is being used in its normal, intended fashion.

Yet another object of the invention is to provide an improved surgical instrument with optical viewing capability in which the fiber optic bundle or bundles are operatively coupled to the instrument over a substantial length thereof such that the maneuverability of the instrument's distal end, having the working element thereon, is not compromised, nor is the surgeon's field-of-view obstructed.

SUMMARY OF THE INVENTION

The foregoing features, objects and advantages of the invention are achieved by providing a variety of surgical instruments that have an elongated rigid shaft with working elements, such as scalpel blades, scissors blades, forceps, rongeurs, stitchers, curettes, or the like, affixed or otherwise disposed at the distal end of the shaft and a handle element affixed to its proximal end. In accordance with the invention, an elongated, flexible, fiber-optic assembly, including at least one illumination fiber and a first image bundle comprising a first plurality of image fibers are secured to the rigid shaft along substantially the entire length thereof, with the distal ends of the illumination fiber and the plurality of image fibers optically aligned with a predetermined portion of the working element. Means are provided at the proximal end of

the illumination fiber for allowing it to be coupled to a light source. Similarly, an appropriate device is affixed to the proximal end of the first image bundle, allowing it to be coupled to a viewing system, such as an eyepiece or a video camera and display.

The illumination fiber and the plurality of image fibers may be contained within a common sheath or, alternatively, may follow differing paths, each of which traverses substantially the entire length of the instrument's rigid shaft. By providing a second image bundle, also including a plurality of image fibers and which is secured to the rigid shaft of the instrument along substantially the entire length thereof with an objective lens at its distal end optically aligned with a predetermined portion of the instrument's working element, a view of the instrument's working element from multiple directions can be realized, thus aiding in the surgeon's depth perception and reducing "shadowing" where the working element blocks the view.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevation view showing the manner in which the present invention may be applied to a conventional surgical scissors;

Figure 2 is a cross-sectional view taken along the line 2-2 in Figure 1;

Figure 3 is a somewhat enlarged perspective view of the distal end portion of the instrument of Figure 1;

Figure 3A is a view like Figure 3, but of a rongeur or of a biopsy forceps;

Figure 4 shows the manner in which the present invention may be applied to a hook knife;

Figure 5 is a cross-sectional view taken along the line 5-5 in Figure 4;

Figure 6 is a cross-sectional view taken along the line 6-6 in Figure 4;

Figure 7 illustrates the invention applied to a surgical stitcher; and

Figure 8 is a distal end view of the device of Figure 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As will become apparent to those skilled in the art from a reading of the following description, the present invention may be applied to various types of specialized medical instruments, including cutting and grasping instruments, surgical probes, stitchers, etc. However, the principles will be explained in connection with only a few specific instruments, namely, a surgical scissors, a rongeur, a hook knife and a stitcher.

Referring to Figure 1, there is indicated generally by numeral 10, a surgical scissors that may find use in minimally invasive procedures, such as a laparoscopic cholecystectomy. The scissors 10 includes an elongated shaft 12 whose outside diameter is such that it can be passed through an introducer, a cannula or directly into a surgical incision and of a length allowing its working element (blades) 14 to reach the organ or tissue to be cut when the scissors handle member 16 affixed to its proximal end is manipulated. The rigid shaft 12 is tubular and its proximal end 18 is fitted into a bore formed in a first handle member 20. Pivotally joined to the first handle member 20 at pivot 22 is a second handle element 24. An actuating rod or cable 26 is appropriately affixed to the upper end of the second handle member 24 and it extends through the lumen of the tubular shaft 12 to join the movable blade 28 of the working element 14. The remaining blade 30 is preferably rigidly secured to the distal end 19 of the rigid shaft 12. By grasping the scissors handle members 20 and 24 by their respective finger-receiving loops 32 and 34 and by pivoting the handle member 24 back and forth relative to the stationary handle half 20, the rod or cable 26 moves reciprocally within the lumen of the rigid tube 12 to cause the movable blade half 28 to open and close in a scissors-like action relative to the stationary blade 30.

The surgical scissors, as thus-far described, is entirely conventional. In accordance with the present invention, however, at least one and preferably two elongated, flexible, fiber-optic assemblies, indicated generally by numerals 36 and 37 are affixed to and routed along substantially the entire length of the elongated rigid shaft 12, such that their distal ends, such as end 38 of assembly 36, is appropriately positioned to allow viewing of the surgical site from the perspective of the scissors blades. (The distal end of fiber-optic bundle 37 is hidden from the view in Figure 1.) By providing two image bundles whose objective lenses are focused on the working element of the instrument from two different perspectives, better depth perception and reduced shadowing can be attained.

As is shown in the cross-sectional view of Figure 2, the actuating rod or cable 26 passes through the lumen 40 of the tube 12 and affixed to the exterior wall of the shaft 12 are the fiber-optic assemblies 36 and 37. Fiber-optic assemblies suitable for use in practicing the present invention may be of the super-thin type disclosed in the Utsumi et al. U.S. Patent 4,867,529. The outside diameter of such "fiberscopes" can be less than about 0.5 mm. Assembly 36 would typically include at least one, but preferably several, illumination fibers 42 and a large plurality, e.g., 10,000, image fibers 44 to provide 10,000 pixel resolution. The image fibers may be about 10 microns in diameter are fused together at each end to thereby preserve their positional relationship relative to one another throughout all or a portion of their entire length of the fiber-optic assembly. The illumination fiber(s) and the plural image fibers may be contained within a common sheath as shown in bundle 36 or, alternatively, the illumination fiber(s) may be routed independently of the image fiber bundle(s). Since the bundle 36 includes an illumination fiber, it is not essential that bundle 37 also

include one, provided the fiber(s) 42 provide adequate illumination.

Referring to the enlarged partial view of the distal end portion of the instrument of Figure 1 illustrated in Figure 3, it is to be noted that an objective lens 46 is affixed to each of the distal ends of the fiber optic bundles 36 and 37 to focus the light rays reflected from the illuminated surgical site onto the plane occupied by the distal ends of all of the image fibers contained within the bundles 36 and 37.

The proximal ends 48 and 49 of the fiber optic assemblies 36 and 37 enter a molded plastic hub member 50 where the illumination fibers 42 are separated from the plurality of image fibers and then brought out through a protective sheath 52 to a connector 54 which is adapted to be connected to a light source. Likewise, the plurality of image fibers are brought out through the hub 50 and through a protective sheath 56 to an appropriate connector 58 which is designed to mate with a viewing system. The viewing system may, in its simplest form, comprise an eyepiece (not shown), which provides direct viewing of the image focused upon the distal end of the image fibers by the objective lens 46. However, the image present at the proximal connector 58 may also be fed to a video camera whose output is transmitted to a viewing screen for indirect observation by the surgeon and the surgical support staff.

It is desirable that the eyepiece or electronic viewing system provide appropriate magnification of the image. This will allow a surgeon to see objects that are otherwise difficult to see with the naked eye. An optical system designed for use in the present invention will have a field-of-view defined by a cone whose apex angle, θ, is in the range of from 50° to 70° when the object being viewed is in an air environment and a range of 37° to 52° if the object is immersed in a saline solution. It will provide a good image of the object placed about 5 mm from the objective lens. A video system used with the above-

described optical arrangement will generate an image on the cathode ray television monitor and the diameter of that image will be approximately D = 5 in. (127 mm) or greater. The magnification can then be computed using the formula:

$$M = ((D/2)/(L\tan\theta/2))$$

where D is the size of the image desired on the CRT screen, L is the distance between the objective lens and the object and θ is a measure of the wideness of the field of view. Using the above formula with the numbers indicated for the various parameters, the magnification, M, to be used is a minimum of 26 times and a maximum of 38 times.

The fiber-optic bundles 36 and 37 may be affixed to the rigid shaft 12 by an appropriate bonding agent, such as epoxy, 60 (Figure 2), in which event the bonding would take place at the manufacturing facility of the instrument rather than in the operating room just prior to use.

Figure 3A shows the manner in which a fiber-optic viewing assembly may be added to a conventional rongeurs forceps. Here, the tubular shaft 12 has cup-like jaws 62 affixed to the distal end thereof and appropriately hinged and connected to an actuator rod 26, the same as in the embodiment of Figure 1. The fiber-optic assemblies 36 and 37 are again routed along substantially the entire length of the shaft 12 with the objective lens 46 arranged along an optical axis so as to be able to view the particular bone or other tissue to be grasped by the cup-shaped forceps paddles 62 when the scissors-style handle of the type shown in Figure 1 is manipulated.

Referring next to Figure 4, there is illustrated the manner in which the present invention may be applied to a surgical hook knife to thereby permit viewing of the nerve, ligament or other tissue to be severed. The hook knife itself is indicated generally by numeral 70 and is conventional. It includes an elongated rigid shaft 72 having a generally rectangular cross-section as best seen in the cross-sectional view of Figure 6. The shaft has a proximal end 74 fitted into a handle member 76 so that it

can be conveniently and comfortably grasped by the surgeon. The shaft 72 is preferably made from stainless steel and its distal end is curved as at 78, terminating in a point 80 and having a beveled cutting edge 82 extending over the inward-facing arcuate portion of the hook.

The instrument of this type is generally used by inserting the shaft 72 of the knife through an opening until the arcuate blade 82 is disposed distally of the tissue to be severed. Cutting takes place by then pulling the knife back in the proximal direction which allows the cutting edge 82 to act upon the tissue to be severed. Carpal tunnel surgery is often performed using this type of instrument.

In accordance with the present invention, at least one fiber-optic assembly is affixed to the instrument in such a way that the surgical site can be viewed, either directly or indirectly, in the manner already described. In particular, a connector 79, which is adapted to mate with a light source, includes illumination fibers that pass through the sheath 81 into a connector hub 83. There they enter the common sheath surrounding the image fibers to form the fiber-optic bundle 84. If desired, the illumination fibers can also be routed separately from the image fibers and extend along side the bundle of image fibers.

Image connector 89 is joined to a plurality of image fibers within the sheath 90 which unite in the hub 82 with the illumination fibers in the fiber-optic bundle 84. This bundle passes through a flexible strain relief member 92 attached to the proximal end of the handle 76 of the hook knife.

The fiber-optic bundle 84 extends along a side surface 88 of the handle 76. Upon leaving the handle surface, bundle 84 is affixed to the exterior upper surface of the rectangular shaft 74. Near the distal end of the shaft, proximate the point where the shaft curves to form the hook, the fiber-optic bundle 84 wraps about the side

surface of the shaft, such that its objective lens 94 becomes optically aligned with the knife edge 82. One observing the image exiting the proximal end of the image fibers in the fiber-optic assembly 84 obtains a remarkably clear view of the surgical site precisely where the blade interacts with the tissue. This adds appreciably to the ability of the surgeon to locate and identify the tissue to be cut.

Figures 7 and 8 show the manner in which the present invention may be applied to an otherwise conventional surgical stitcher, such as the Acufex® Meniscal Stitcher, used in arthroscopic knee surgery. It is seen to comprise an elongated rigid tubular shaft 96 having lumens 98 and 100 extending from its proximal end to its distal end. Surrounding the proximal end of the shaft 96 is a knurled handle member 104. The lumens 98 and 100 accommodate stitching needles as at 106 and 108.

Affixed to the exterior of the shaft 96 is an optical fiber assembly 110 including an illumination fiber or bundle 114 and an image bundle 116 (Figure 8). Appropriately attached to the distal ends of the image fibers 116 is an objective lens positioned to view the distal end portions of needles 106 and 108 exiting the lumens in the shaft 96.

The illumination fibers are brought out through a hub member 118 to a connector 120, which is adapted to mate with a jack on a suitable light source (not shown). Similarly, the image fibers pass through the hub 118 and terminate in a connector 122 adapted to mate with the image input to a suitable viewing device, such as a video camera and associate video display.

In use, the rigid tubular shaft 96 acts as an introduction cannula and it is passed through a small surgical opening into the knee joint space so that its distal end can be brought up against the meniscus at a desired location. By viewing the image presented by the reflected light rays passing through the image fibers, the

surgeon is able to precisely locate the distal end of the cannula at the desired site. The cannula is oriented so that the needles 106 and 108, having been inserted the entire length of the shaft 96, will pierce both sides of the tear in the meniscus to be repaired and will continue on through the capsule and soft tissues until the needle points pierce the skin opposite the entry portal. The needles, with a long strand of suture material 124 passing through their eyes, are then pulled out of the tissues and the loop of suture is drawn taut so as to complete the internal half of the stitch. A knot is then tied and drawn tight against the outer surface of the capsule through a small incision bridging the exit perforations of the needles. This procedure may be repeated as many times as necessary to effect repair of the tear.

The utility of the present invention can be appreciated upon considering a typical arthroscopic surgical procedure. In conventional arthroscopic surgery, it is necessary to make a plurality of punctures through the skin and into the capsule of a joint. Through this plurality of percutaneous punctures, also called "operating portals", tools are passed. One tool commonly used is a meniscus cutter. In conventional, prior art arthroscopic surgical procedures, the action of a meniscus cutter, passed through one of the operating portals, is observed with a separate instrument, namely, a rigid endoscope termed an arthroscope. It is passed through a second operating portal different from the one accommodating the meniscus cutter. One or more of a second type of percutaneous punctures, called "irrigation portals", may also be made through the skin and into the joint capsule. Irrigation fluid, which distends the joint and sweeps away blood clouded fluid, may be injected through and removed from the irrigation portals. While irrigation portals are generally of a small diameter, operating portals must necessarily be large enough to pass surgical tools and

arthroscopes. It is, of course, desired to limit the number of operating portals required for surgery.

By using the instrument of the present invention, it is no longer necessary to use a separate rigid arthroscope in that the viewing optics would be adhered to the exterior surface of the meniscus cutter, thus obviating the need for a relatively large operating portal which would otherwise be used to accommodate that arthroscope.

It should be apparent to those skilled in the art that by appending the optical fiber assemblies to the surgical instruments along substantially the entire length of a rigid shaft portion of those instruments, the surgeon will still receive the desirable tactile response from the instrument. Also, better balance is retained than can be achieved when a conventional flexible endoscope is clipped only onto the distal end portion of the instrument as in the aforereferenced Cawood '348 patent. Because the fiber-optic assemblies are made to conform to the profile of the instrument, it can be passed through a significantly smaller incision or through the lumen of a cannula or introducer, a result that cannot be attained with the arrangement shown in the Cawood patent.

This invention has been described herein in considerable detail in order to comply with the Patent Statutes and to provide those skilled in the art with the information needed to apply the novel principles and to construct and use such specialized components as are required. However, it is to be understood that the invention can be carried out by specifically different equipment and devices, and that various modifications, both as to the equipment details and operating procedures, can be accomplished without departing from the scope of the invention itself.

What is claimed is:

CLAIMS

1. A surgical instrument comprising:

(a) an elongated rigid shaft having a proximal end and a distal end;

(b) a working element disposed at said distal end of said shaft for manipulating tissue during the course of a surgical procedure;

(c) a handle element affixed to said proximal end of said shaft for facilitating the movement of said working element;

(d) an elongated flexible fiber optic assembly including a first plurality of image fibers having a proximal end and a distal end with an objective lens affixed to said distal end of said first plurality of image fibers for defining a predetermined field-of-view;

(e) means at said proximal end of said first plurality of image fibers for coupling same to a viewing system; and

(f) means for securing said fiber optic assembly to said rigid shaft along substantially the entire length thereof with said distal end of said first plurality of image fibers positioned with a predetermined portion of said working element within said field-of-view.

2. The surgical instrument as in Claim 1 wherein said means for securing said assembly to said rigid shaft comprises a bonding agent.

3. The surgical instrument as in Claim 2 wherein said bonding agent is an epoxy.

4. The surgical instrument as in Claim 1 and further including at least one illumination fiber secured to said rigid shaft along substantially the entire length thereof with said illumination fiber having a distal end that is positioned to project light on said predetermined portion of said working element.

5. The surgical instrument as in Claim 1 wherein said viewing system includes a video camera and means for displaying the image perceived by said video camera.

6. The surgical instrument as in Claim 5 wherein said video camera provides an optical magnification of at least 25 times.

7. The surgical instrument as in Claim 1 wherein said working element comprises a hook knife blade.

8. The surgical instrument as in Claim 1 wherein said working element comprises a scissors blade.

9. The surgical instrument as in Claim 1 wherein said working element comprises a rongeurs.

10. The surgical instrument as in Claim 1 wherein said working element comprises stitching needles.

11. The surgical instrument as in Claim 1 wherein said flexible fiber optic assembly is adhered to the exterior of said elongated rigid shaft.

12. The surgical instrument as in Claim 11 wherein said rigid shaft includes a groove in said exterior surface and at least a portion of said flexible fiber optic assembly is disposed in said groove.

13. The surgical instrument as in Claim 4 wherein said illumination fiber and said first plurality of image fibers are contained within a common sheath.

14. The surgical instrument as in Claim 4 wherein said at least one illumination fiber and said first plurality of image fibers follow differing paths which traverse substantially the entire length of said rigid shaft.

15. The surgical instrument as in Claim 1 and further including:

(a) a second plurality of image fibers having proximal ends, distal ends and an objective lens affixed to said distal ends;

(b) means for securing said second plurality of image fibers to said rigid shaft along substantially the entire length thereof, the ends of said second plurality of image fibers being disposed in viewing relation with a predetermined portion of said working element along a

viewing axis which is different from that of said first plurality of image fibers.

16. The surgical instrument as in Claim 15 and further including means for coupling said proximal ends of said second plurality of image fibers to said viewing system to provide multiple independent views of said predetermined portion of said working element.

17. The surgical instrument as in Claim 16 wherein said viewing system includes a video camera and means for displaying the image perceived by said video camera.

18. The surgical instrument as in Claim 17 wherein said video camera provides an optical magnification of at least 25 times.

19. The surgical instrument as in Claim 16 wherein said working element comprises a scissors blade.

20. The surgical instrument as in Claim 16 wherein said working element comprises a rongeurs forceps.

21. The surgical instrument as in Claim 16 wherein said working element comprises stitching needles.

22. The surgical instrument as in Claim 16 wherein said first and second plurality of image fibers and said at least one illumination fiber are adhered to the exterior of said elongated rigid shaft.

23. The surgical instrument as in Claim 22 wherein said rigid shaft includes a pair of grooves in said exterior surface and at least a portion of each of said first and second plurality of image fibers are disposed individually in said pair of grooves.

24. In combination with a surgical instrument having handle, body and distal end working portions, a super-thin light guide comprises of one or more light transmitting fibers (said light transmitting fibers being less than about 0.5 mm in diameter), a super-thin image guide with distal lens for magnification, said guide being comprised of a plurality of fused fibers each of which is less than about 10 microns in diameter; and means for attaching said light guide and said image guide in predetermined positions

at said instrument distal end working portion for establishing a magnified field of view of a work area, the guides also being attached to the body of the instrument.

25. A method of performing a surgical procedure comprising the steps of:

(a) surgically creating a opening leading to a surgical site;

(b) providing a surgical instrument having an elongated rigid shaft with a proximal end and a distal end, there being a working element at said distal end of said shaft for manipulating tissue, a handle element affixed to said proximal end of said shaft and an elongated, flexible fiber-optic assembly, said assembly including a plurality of image fibers with an objective lens at the distal end of said image fibers for defining a field-of-view, said fiber-optic assembly being secured to said rigid shaft along substantially the entire length thereof, said working element falling within said field-of-view;

(c) connecting a proximal end of said image fibers to a viewing device; and

(d) inserting said surgical instrument into said opening and advancing said working element to said surgical site while observing said viewing device.

AMENDED CLAIMS

[received by the International Bureau on 1 March 1994 (01.03.94); original claims 11 and 22 cancelled; original claims 1,4,12,15 and 23-25 amended and renumbered accordingly; other claims unchanged but renumbered (4 pages)]

1. A surgical instrument comprising:

(a) an elongated rigid shaft having a proximal end and a distal end;

(b) a working element disposed at said distal end of said shaft for manipulating tissue during the course of a surgical procedure;

(c) a handle element affixed to said proximal end of said shaft for facilitating the movement of said working element;

(d) an elongated flexible fiber optic assembly including a first plurality of image fibers having a proximal end and a distal end with an objective lens affixed to said distal end of said first plurality of image fibers for defining a predetermined field-of-view;

(e) means at said proximal end of said first plurality of image fibers for coupling same to a viewing system; and

(f) means for securing said fiber optic assembly to the exterior of said rigid shaft along substantially the entire length thereof with said distal end of said first plurality of image fibers positioned with a predetermined portion of said working element within said field-of-view.

2. The surgical instrument as in Claim 1 wherein said means for securing said assembly to said rigid shaft comprises a bonding agent.

3. The surgical instrument as in Claim 2 wherein said bonding agent is an epoxy.

4. The surgical instrument as in Claim 1 and further including at least one illumination fiber secured to the exterior of said rigid shaft along substantially the entire length thereof with said illumination fiber having a distal end that is positioned to project light on said predetermined portion of said working element.

5. The surgical instrument as in Claim 1 wherein said viewing system includes a video camera and means for displaying the image perceived by said video camera.

6. The surgical instrument as in Claim 5 wherein said video camera provides an optical magnification of at least 25 times.

7. The surgical instrument as in Claim 1 wherein said working element comprises a hook knife blade.

8. The surgical instrument as in Claim 1 wherein said working element comprises a scissors blade.

9. The surgical instrument as in Claim 1 wherein said working element comprises a rongeurs.

10. The surgical instrument as in Claim 1 wherein said working element comprises stitching needles.

11. The surgical instrument as in Claim 1 wherein said rigid shaft includes a groove in said exterior surface and at least a portion of said flexible fiber optic assembly is disposed in said groove.

12. The surgical instrument as in Claim 4 wherein said illumination fiber and said first plurality of image fibers are contained within a common sheath.

13. The surgical instrument as in Claim 4 wherein said at least one illumination fiber and said first plurality of image fibers follow differing paths which traverse substantially the entire length of said rigid shaft.

14. The surgical instrument as in Claim 1 and further including:

(a) a second plurality of image fibers having proximal ends, distal ends and an objective lens affixed to said distal ends;

(b) means for securing said second plurality of image fibers to the exterior of said rigid shaft along substantially the entire length thereof, the ends of said second plurality of image fibers being disposed in viewing relation with a predetermined portion of said working element along a viewing axis which is different from that of said first plurality of image fibers.

15. The surgical instrument as in Claim 14 and further including means for coupling said proximal ends of

said second plurality of image fibers to said viewing system to provide multiple independent views of said predetermined portion of said working element.

16. The surgical instrument as in Claim 15 wherein said viewing system includes a video camera and means for displaying the image perceived by said video camera.

17. The surgical instrument as in Claim 16 wherein said video camera provides an optical magnification of at least 25 times.

18. The surgical instrument as in Claim 15 wherein said working element comprises a scissors blade.

19. The surgical instrument as in Claim 15 wherein said working element comprises a rongeurs forceps.

20. The surgical instrument as in Claim 15 wherein said working element comprises stitching needles.

21. The surgical instrument as in Claim 15 wherein said rigid shaft includes a pair of grooves in said exterior surface and at least a portion of each of said first and second plurality of image fibers are disposed individually in said pair of grooves.

22. In combination with a surgical instrument having handle, body and distal end working portions, a super-thin light guide comprises of one or more light transmitting fibers (said light transmitting fibers being less than about 0.5 mm in diameter), a super-thin image guide with distal lens for magnification, said image guide being comprised of a plurality of fused fibers each of which is less than about 10 microns in diameter; and means for attaching said light guide and said image guide in predetermined positions at said instrument distal end working portion for establishing a magnified field of view of a work area, the guides also being attached to the body of the instrument.

23. A method of performing a surgical procedure comprising the steps of:

(a) surgically creating a opening leading to a surgical site;

(b) providing a surgical instrument having an elongated rigid shaft with a proximal end and a distal end, there being a working element at said distal end of said shaft for manipulating tissue, a handle element affixed to said proximal end of said shaft and an elongated, flexible fiber-optic assembly, said assembly including a plurality of image fibers with an objective lens at the distal end of said image fibers for defining a field-of-view, said fiber-optic assembly being secured to the exterior of said rigid shaft along substantially the entire length thereof, said working element falling within said field-of-view;

(c) connecting a proximal end of said image fibers to a viewing device; and

(d) inserting said surgical instrument into said opening and advancing said working element to said surgical site while observing said viewing device.

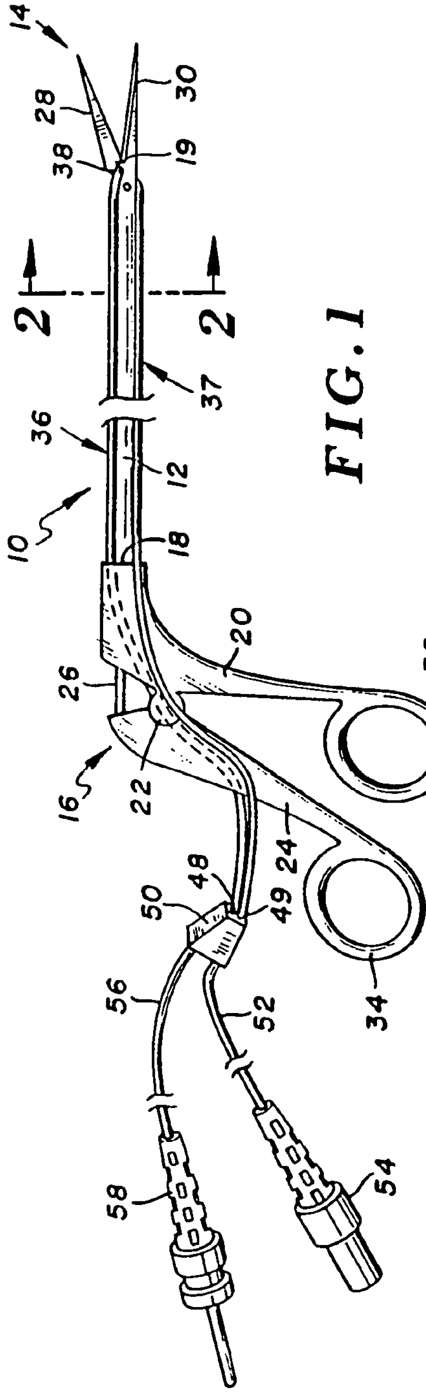

FIG. 1

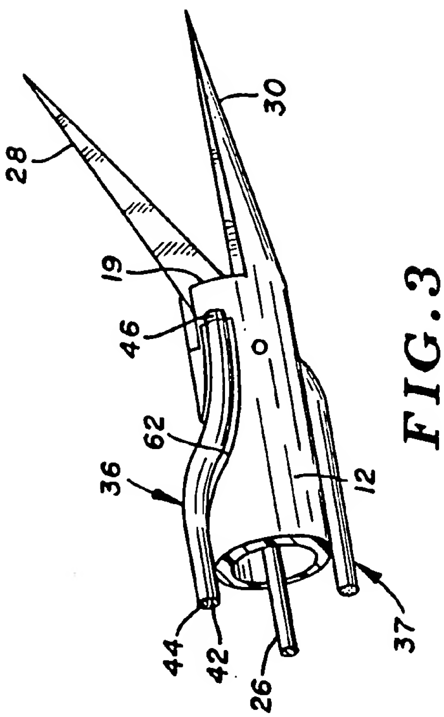

FIG. 3

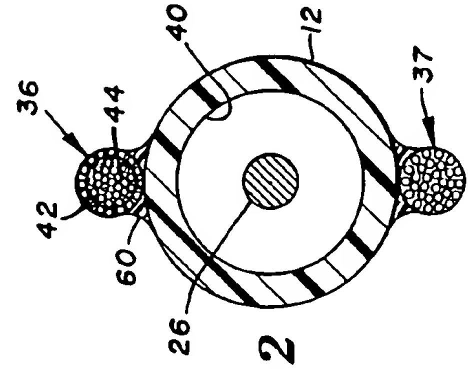

FIG. 2

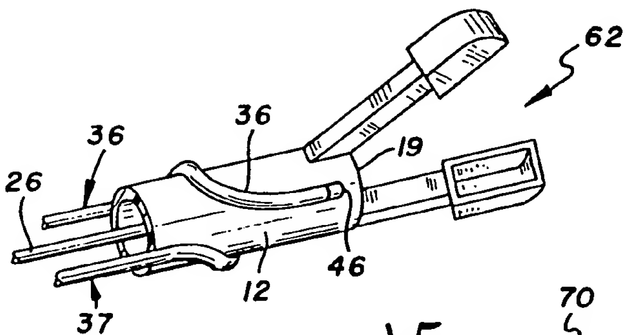

FIG. 3A

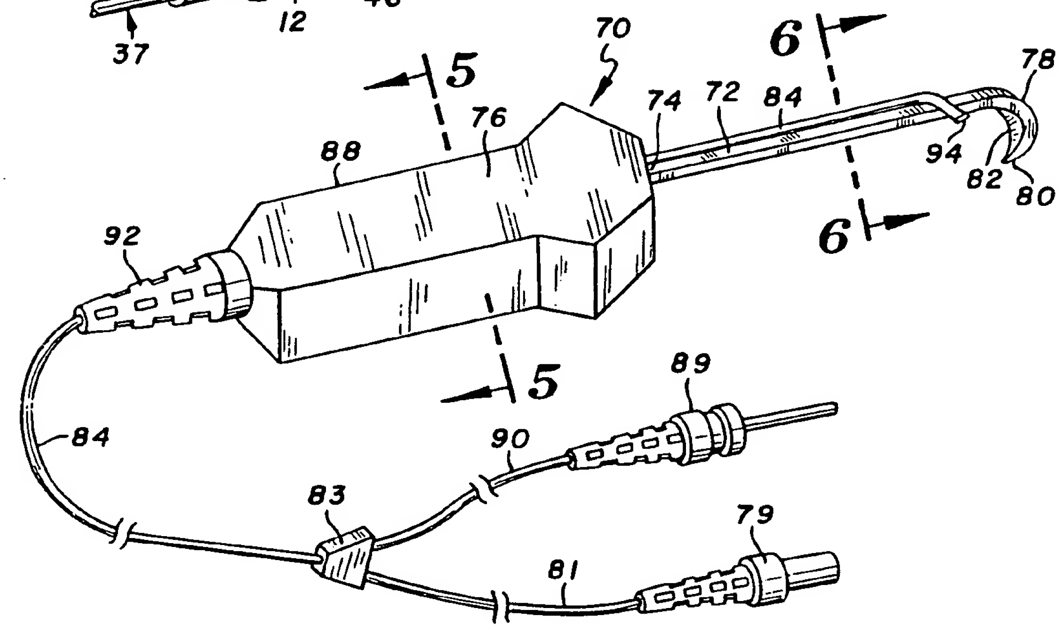

FIG. 4

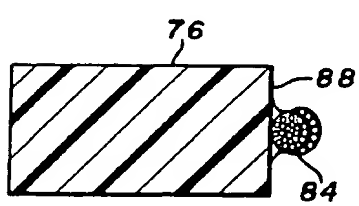

FIG. 5

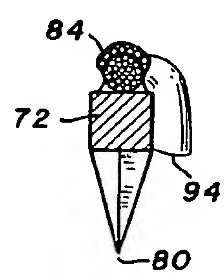

FIG. 6

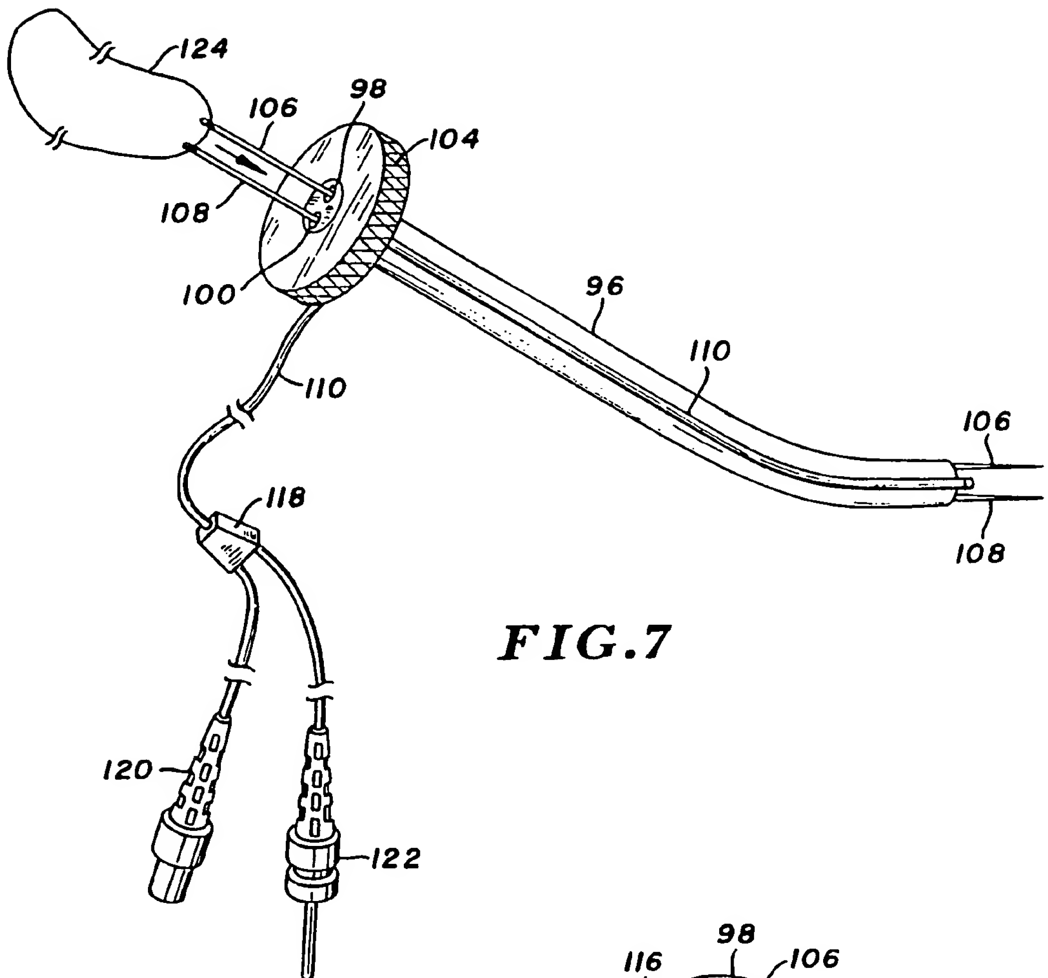
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FIG.7

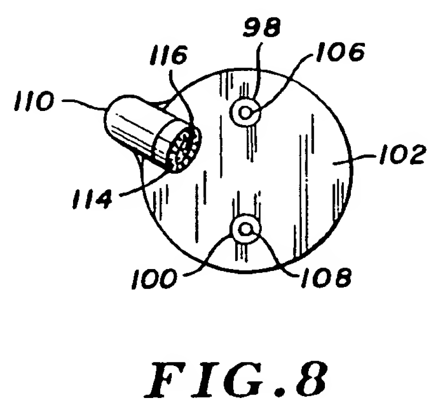
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FIG.8

INTERNATIONAL SEARCH REPORT

PCT/US92/09616

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61B 17/36,1/00

US CL :128/4,6,395; 606/15

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/396,397,398; 606/13,14,16,83,127,167,170,179,180,205,210,211; 385/117

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,759,348 (CAWOOD) 26 July 1988, Note figure 1, abstract.	1,4,11,13,25 2,3,5-10,24
Y	US, A, 5,147,356 (BHATTA) 15 September 1992, Note column 2, lines 57-65.	12
Y	US, A, 4,867,529 (UTSUMI ET AL.) 19 September 1989, Note Abstract: super thin scope.	24
A	US, A, 300,564 (FURIHATA) 17 November 1981, Note figure 3.	1-13,24,25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 JANUARY 1993	08 FEB 1993

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